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Discrete Optimization

# The one-dimensional cutting stock problem with usable leftover – A heuristic approach

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ABSTRACT

In this work we consider a one-dimensional cutting stock problem in which the non-used material in the cutting patterns may be used in the future, if large enough. This feature introduces difficulties in comparing solutions of the cutting problem, for example, up to what extent a minimum leftover solution is the most interesting one when the leftover may be used. Some desirable characteristics of good solutions are defined and classical heuristic methods are modified, so that cutting patterns with undesirable leftover (not large enough to be used, nor too small to be acceptable waste) are redesigned. The performance of the modified heuristics is observed by solving instances from the literature, practical instances and randomly generated instances.



## 1. Introduction

Cutting stock problems (CSP) consist in cutting large pieces (*objects*), available in stock, into a set of smaller pieces (*items*) in order to fulfill their requirements, optimizing a certain objective function, for instance, minimizing the total number of objects cut, minimizing waste, minimizing the cost of the objects cut, etc. These problems are relevant in the production planning of many industries such as the paper, glass, furniture, metallurgy, plastics and textile industries.

In the last four decades cutting stock problems have been studied by an increasing number of researchers. The interest in these problems can be explained by their practical application and the challenge they offer to academia. For despite their apparent simplicity, they are, in general, computationally difficult to solve.

Due to the diversity of situations where CSP arise, we are always faced with new constraints and/or objectives for which the available methods are of limited value. Hence, the use of simple heuristics has been observed in practice, many without any evaluation of their performance.

Although frequently arising in practical situations, we could not find many articles in the literature that consider the situation where the leftover material may be used to cut future demands, if large enough. We call leftover any piece cut that is not a required item. To the best of our knowledge only Gradisar et al. (1997, 1999a,b), Gradisar and Trkman (2005) and Abuabara (2006) consider this possibility. In 1997, Gradisar et al. proposed a heuristic (denoted by COLA) to optimize roll cutting in the textile industry with the objective of creating a cutting plan with reduced leftovers or to concentrate them into a single object. All objects have different lengths and they propose a bi-objective function that minimizes the number of unfulfilled item demands and the total loss (sum of the leftover smaller or equal to a pre-defined value). In 1999, Gradisar et al. proposed a modified COLA (denoted by CUT) and in 2005, Gradisar and Trkman developed an algorithm to find a solution to general one-dimensional cutting stock problems with distinct objects, starting from the solution obtained by CUT and replanning patterns that do not satisfy some criteria. In 2006, Abuabara modified the mathematical model proposed by Gradisar et al. (1997), decreasing its size, that is, reducing the number of constraints and variables in the model.

In this work we present some characteristics of a desirable solution (we avoid "optimal solution" since a criterion to compare solutions is not defined) to the cutting stock problem with usable leftover (CSPUL). Modifications on classical heuristic methods to solve CSP are suggested aiming to find a solution that satisfies those characteristics.

This article is organized as follows: in Section 2, the CSPUL is defined. Some methods to solve it are presented in Sections 3 and 4. Computational tests are presented in Section 5 and concluding remarks and future works are presented in Section 6.

## 2. Definition of the cutting stock problem with usable leftover

During the cutting process, unavoidable leftovers occur that are often discarded. Some industries, however, have the possibility of

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